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Structural Equation Model of Students' Interest, Motivation, Self-Efficacy, Persistence, and Perceived Teaching Quality in Mathematics

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Abstract. Understanding the psychological variables of learning mathematics at the high school level is important to designing effective teaching strategies that improve their active engagement and academic achievement in mathematics. This study validated the assumptions of the Self-Determination Theory and Social Cognitive Theory in the context of mathematics classroom learning. This research aims to fill the gap in the literature by confirming a structural equation model based on two combined theories, incorporating the latent variables of self-efficacy, persistence, interest, motivation to learn mathematics, and the perceived teaching quality, areas that have already been explored in previous studies. Data were gathered from 325 selected public high school students (junior and senior high school) using a multivariate-correlational research design. Results revealed that self-efficacy strongly influences motivation ($\beta=0.823$, $p<0.001$) and weakly influences persistence ($\beta=0.267$, $p=0.003$), while perceived teaching quality significantly impacts interest ($\beta=0.769$, $p<0.001$) and self-efficacy ($\beta=0.328$, $p<0.001$). Additionally, student interest enhanced self-efficacy moderately ($\beta=0.471$, $p<0.001$), further reinforcing its critical role in fostering confidence. Motivation to learn mathematics was found to be strongly associated with students' persistence ($\beta=0.557$, $p<0.001$). These findings led to developing a valid and reliable structural equation model characterized by strong psychometric properties and excellent model fit indices. The results profoundly emphasize the interplay of psychological and instructional factors in promoting engagement, motivation, and resilience among high school mathematics learners, offering valuable insights for enhancing teaching strategies and educational policies. High school students should cultivate self-efficacy and motivation in mathematics through self-reflection and goal-setting. Teachers are encouraged to adopt interactive, real-world strategies that enhance interest and confidence, while school leaders should focus on professional development to sustain student engagement. Future research can explore digital tools, gamification, and advanced statistical modeling to investigate non-cognitive factors shaping mathematics learning.

Keywords: Motivation; Perceived teaching quality in Mathematics; Persistence; Self-efficacy; Structural Equation Model; Student interest.

1.0 Introduction

Mathematics education fosters intellectual growth, logical reasoning, and understanding of other disciplines. According to the International Commission on Mathematics Instruction (2024), mathematics is essential for human reasoning and understanding the world. Moreover, mathematical knowledge is vital for comprehending other academic disciplines, including science, social studies, music, and art. These indicate that students are trained to become critical thinkers and problem-solvers in learning mathematics. The Department of Education Philippines (2023) emphasized in the Revised K-12 (MATATAG) Curriculum that developing mathematical proficiency and critical thinking skills in learners is crucial for addressing real-world challenges effectively. Moreover, Young (2003) stated that many modern technological advancements are owed to the brilliant minds who applied mathematical thinking, which led to the creation of various products people enjoy today. Mathematics education plays a critical role in students' cognitive development, yet the psychological factors influencing their success are complex and multifaceted. Teaching students mathematical skills and critical thinking is vital in the present century for solving real-world problems and contributing to development and progress (Rusczyk, n.d; Firdaus et al., 2015; Syafril et al., 2020). Therefore, examining the variables that profoundly affect the teaching-learning process of mathematics is essential.

Teachers play a significant role in the academic success of students. Kamayubonye and Mutarutinya (2023) proved this notion by finding that aspects of quality teaching mathematics affect the student's learning in Mathematics. In the current generation, it is with utmost concern that we focus on the individual psyche of students when it comes to learning and the substantial factors involved. Students nowadays learn differently, which makes teaching strategies more realistic and student-centered. Each new generation of students we teach requires different teaching and learning strategies (Gurnon, 2020). The Social Cognitive Theory of A. Bandura emphasizes that learning occurs within a social context (Nickerson, 2024). Learning occurs through observing the behavior of others. In the context of education, students can learn from the modeled behaviors of their teachers. High-quality teaching that makes lessons engaging and relevant can spark students' interest in mathematics (Great Minds, n.d.). Resnick and Boltz (2019) stated in their online article that self-efficacy is the belief in one's ability to plan and carry out actions to accomplish a particular goal. Self-efficacy is related to this theory (LaMorte, 2022). It is the desirable change observable in students, reflecting their increased confidence and capability to engage in and persist with tasks, enhancing their overall performance and outcomes.

The motivation to learn mathematics is connected to the self-efficacy and persistence of the students (Osic & Tanaid, 2023; Detrina, 2016; Selden & Selden, 2013). The Theory of Self-determination of Ryan and Deci (2000) indicates that when students' basic psychological needs for autonomy, competence, and relatedness are satisfied, their intrinsic motivation increases. This heightened intrinsic motivation can lead to greater self-efficacy and persistence in learning, as students feel more capable and committed to engaging with mathematical tasks. Moreover, Ariff et al. (2022) revealed that self-efficacy is related to academic motivation. When students believe they can achieve a task in mathematics, their intrinsic motivation is likely higher (Velez & Abuzo, 2024). The interplay of students' motivation, self-efficacy, and persistence is essential for their overall academic success and long-term engagement in mathematics. However, achieving better academic achievement and good study habits remain the top challenges as students must continuously navigate various academic and personal obstacles to sustain their motivation and commitment to learning (Bandala, 2023; Sakirudeen & Sanni, 2017).

Bandala (2023) identified several key issues affecting students' academic performance, including low study habits, moderate parental support, and high technology use. These challenges contribute to difficulties in learning mathematics, with students experiencing a loss of interest, struggles with understanding concepts, anxiety, and varying teaching styles. To address these issues, Bandala suggested implementing a guidance intervention program. Similarly, Casinillo (2019) examined factors influencing students' failure rates in mathematics at Visayas State University, revealing that poor study habits, negative learning attitudes, social and emotional problems, and financial issues play significant roles. The Philippine News Agency (2023) highlighted a concerning trend, the Philippines ranking third from the bottom in science, sixth in mathematics, and sixth in reading according to the PISA 2022 results. This is corroborated by the National Achievement Test (NAT) results, which showed low performance among Filipino students in critical thinking, problem-solving, and information literacy (Branzuela et al., 2023; Philippine Star, 2024). Furthermore, recent evidence gathered by the researcher from three public high schools in Pasig City and Marikina City revealed inconsistencies in class attendance and achievement test results in Mathematics, Science, and English among both junior and senior high school learners. These problems are closely linked to self-efficacy, motivation to learn math, interest, persistence, and teaching quality, as they underscore how various factors, such as inadequate study habits and emotional challenges, can significantly impact students' overall academic engagement and performance.

Metro Manila, with a population exceeding 13.4 million, is among the world's most densely populated urban areas (Aboitiz Infra Capital, n.d.). This led the researcher to select this area as the study locale, choosing two municipalities with a significant number of high school students. High school learners experience a significant transformation in cognitive abilities, moving from concrete operational thinking to formal operational thinking, as discussed by Jean Piaget. This transition, characterized by the development of abstract reasoning and deductive logic, typically occurs during early adolescence and into the teenage years, coinciding with puberty (The Education Hub, 2021). The cognitive development stage that high school learners go through is critical to shaping their ability to think critically, abstractly, and creatively. These skills are paramount in the 21st century, highlighting the need for educational systems to prioritize effective teaching practices that enhance cognitive abilities (Cherry, n.d.). Hence, understanding how self-efficacy, persistence, interest, motivation, and perceived teaching quality interact is important for enhancing high school students' cognitive development and ensuring academic success.

Recent studies have already explored self-efficacy, persistence, interest, motivation to learn mathematics, and the quality of instruction, deriving models through correlational and regression analyses (Nazareth-Tanaid & Osic, 2023; Tambunan et al., 2021; Schweder & Raufelder, 2022). Although these studies focused on various research objectives, they did not produce a comprehensive structural model. Given the absence of a statistical model that integrates self-efficacy, motivation, interest, persistence, and perceived teaching quality, and considering the current challenges students face in learning mathematics, the researcher is motivated to confirm a model that combines the assumptions of Social Cognitive Theory and Self-Determination Theory. This model aims to address academic struggles by providing a structured quantitative approach to enhance student engagement and performance in mathematics. Moreover, this statistical model can be utilized to craft academic policies to improve mathematics learning at the basic education level.

2.0 Methodology

2.1 Research Design

This current research employed a multivariate quantitative research design and is confirmatory. Covariance-Based Structural Equation Modeling tests hypotheses and theoretical models by analyzing the relationships between observed and latent variables (Hair et al., 2019; Byrne, 2016). Covariance-Based Structural Equation Modeling is a statistical method used when testing or confirming a theory based on the relationships between observed variables and their underlying latent constructs, allowing researchers to assess the fit of their theoretical model to the collected data (PARSSU, 2022). This study examines the interrelationships among self-efficacy, interest, motivation to learn math, persistence, and teaching quality through the lens of Bandura's Social Cognitive Theory and Ryan and Deci's Self-Determination Theory (2000). Furthermore, this study also used a multivariate method of analyzing relationships between observed and latent variables, as Civelek (2018) and Fan et al. (2016) discussed in their paper.

2.2 Research Locale

The study was conducted in two urbanized cities in the eastern area of Metro Manila, Pasig City and Marikina City. Two big schools from the former and one big school from the latter were randomly selected, and high school students from diverse backgrounds were selected using simple random sampling. Pasig City Hall Library (2021) revealed that the city has attained the fourth rank in terms of population in the National Capital Region, and around 35% of it are high school students. In addition, the Department of Education – Marikina (n.d.) reported that there are currently 30 secondary schools with enough students. Therefore, the researchers selected these cities as the study's locale due to their ample population of public high school students. This substantial number of learners ensures a robust sample size, essential for generating statistically significant results.

2.3 Research Participants

The respondents of this present study were 325 high school students (junior high school and senior high school) from the municipalities of Pasig City and Marikina City. In measuring the perceived teaching quality, the study considered students and school administrators (head teachers and school heads) respondents of the chosen schools. Selected schools with a corresponding number of respondents were School A (120), School B (110), and School C (95) during SY 2023-2024. Twenty-seven head teachers and three school heads participated in the survey. The sample size of 325 exceeded the required minimum of 223, which was determined by the researcher using the

Daniel Soper Sample Size Calculator. This calculation was based on a 95% estimated power of the test, a 5% significance level, an estimated effect size of 0.30, 24 manifest variables, and 5 latent variables.

The researcher employed simple random sampling to select the high school respondents from the three different schools. This type of probability sampling ensures that every member of the population of interest has a chance of being included in the study (Calmorin & Calmorin, 2007). This is aligned with the notion that random samples are valid for making statistical inferences, as pointed out by Yambot (2020) and Mananghaya (2020) of the University of the Philippines Los Banos.

2.4 Research Instrument

The researcher adapted and contextualized several scales specifically for high school students and mathematics learning: the Self-Efficacy Scale, Motivation Scale, Persistence Scale, Teaching Quality Scale, and Student Interest Scale. The motivation scale indicators were derived from Nurkarim et al. (2023). The persistence scale items were based on Ogbu and Ugwu's (2023) validation study. The perceived teaching quality scale was structured from the studies of Leon et al. (2017) and Çiftçi and Karadağ (2016). The self-efficacy and student interest scales were constructed following the research of Dullas (2018) and Luo et al. (2019). Furthermore, six experts were consulted to evaluate the scale to ensure face and content validity. This process resulted in an overall scale content validity index of 0.850, indicating good validity. Each scale is structured in a five-point Likert system to determine the respondents' level of agreement in each indicator: 4 – Strongly Agree, 3 – Agree, 2 – Disagree, and 1 – Strongly Disagree. Note that the following were used as a range of verbal interpretation: 1.00 – 1.80 (Strongly Disagree), 1.81 – 2.60 (Disagree), 2.61 – 3.40 (Neither Agree nor Disagree), 3.41 – 4.20 (Agree) and 4.21 – 5.00 (Strongly Agree).

After conducting Confirmatory Factor Analysis (CFA) to ensure construct validity, two items were removed from the Teaching Quality scale, one from the Motivation Scale, three from the persistence scale, and one from the Interest scale due to low standardized regression weights and high residual covariances. The remaining items form reliable and valid measures, as evidenced by strong internal consistency and significant factor loadings. These items comprehensively cover the construct based on theoretical and empirical grounds. While a more significant number of items is often preferred, the remaining number maintains the essential components of each scale and offers a parsimonious yet effective measure. Additionally, composite reliability, convergent validity, and discriminant validity results were reported in the discussion to highlight the robustness and accuracy of the refined scales.

2.5 Data Gathering Procedure

The researcher asked permission from the Schools Division Offices of Pasig City and Marikina City and the principal of the three randomly selected high schools. After receiving the approved letter, the researcher administered the actual hard copies of the survey to the respondents, coupled with a short orientation about the study's objective and its relevance to them as students. Informed consent was also distributed to the student respondents and their parents. These were given prior to the actual administration of the survey. Clear instructions were provided to them, and the student-respondents were given assurance that their responses and any information about them were treated with strict confidentiality and anonymity.

Two weeks after the data collection, the researcher organized and tabulated the students' responses to Microsoft Excel. Before tabulating the data, it was thoroughly inspected and cleaned to ensure no missing entries. The data were thoroughly processed and organized using Microsoft Excel. For analysis, SPSS Version 26 was utilized to handle statistical procedures, while SPSS AMOS and Master Validity of James Gaskin were employed for scale validation and structural equation modeling.

2.6 Data Analysis

The researcher solely utilized Covariance-Based Structural Equation Modeling (CB-SEM) as the primary statistical method because the study aimed to confirm the essence of the combined concepts of Social Cognitive Theory and Self-Determination Theory relative to the relationships among the teaching-learning variables of mathematics, such as students' self-efficacy, motivation to learn, interest, persistence, and perceived teaching quality. Civelek (2018) and PARSSU (2022) pointed out that this type of structural equation modeling is appropriate since it is intended for theory testing and comparing possible alternatives based on iterations and adjustments made.

Moreover, this type of SEM was used because the data set obtained achieves both univariate normality and multivariate normality. Using the Shapiro-Wilk Test, each p-value per observed variable is more significant than 0.05. In AMOS, the critical value ratio of 0.945 in the multivariate normality falls between the values -1.96 to 1.96. This indicates that the data meets the assumption of multivariate normality, as the critical value ratio lies within the acceptable range.

Moreover, confirmatory factor analysis (CFA) was conducted as part of the procedures in structural equation modeling. This is to validate the measurement model. This was necessary to confirm that the observed variables accurately reflect the underlying theoretical constructs. The CFA ensured that the constructs, such as students' self-efficacy, motivation, interest, persistence, and teaching quality, were measured reliably and consistently, providing a solid foundation for subsequent analysis and interpretation of the relationships among these variables in the context of mathematics education. In conducting the CB-SEM analysis, the researcher presented standardized coefficients, p-values, and model fit statistics.

2.7 Ethical Considerations

Potential ethical issues and concerns arise about the respondent's participation in this study. Respondents voluntarily completed the survey and felt they were not pressured to participate. A face-to-face orientation was conducted per class section to fully explain the contents of the questionnaire and establish a bond with the respondents. Orientations were conducted outside of class schedules to ensure no disruption to their classes. Data collection and storage of data conformed to the strict guidelines of ethical standards. The personal identities of the participants were not gathered. Moreover, respondents, the majority of belonging to minors age, were given parental consent and informed consent to ensure ethical compliance and protect their rights throughout the study. No information about the respondents and their responses was archived or released in research publications, online, or public repositories.

Pertinent files (including the digital forms) such as actual responses in the survey, correspondences with respondents and parents, and approved letters from the Schools Division Offices were stored in a password-templated folder in the researcher's personal computer. Back-up files were also stored in a safe password-protected file. Direct communication with the respondents and their parents (including the informed consent) was deleted one week after the data analysis and interpretations were conducted. Important files were destroyed in March 2024, three months after the research project concluded, to provide researchers time to identify potential data for use as a reference in future investigations. The findings from this study were disseminated through scientific journals, presentations, and reports, using data that has been anonymized to protect participant privacy.

3.0 Results and Discussion

3.1 Confirmatory Factor Analysis

Table 1 presents the results of conducting Confirmatory Factor Analysis in terms of the factor loadings of each item with the associated p-values. The factor loadings in the matrix indicate strong relationships between the observed items and their respective latent constructs, with all values exceeding the commonly accepted threshold of 0.70 and p-values less than 0.05. This demonstrates the reliability and statistical significance of the items in measuring constructs such as Perceived Teaching Quality, Interest, Persistence, Motivation, and Self-Efficacy. According to Hair et al. (2009), as cited by PARSSU (2022), factor loadings should exceed the 0.50 threshold and demonstrate statistical significance to ensure validity.

Notably, the highest loadings, such as IT3 (0.873), P2 (0.913), and SE3 (0.876), highlight these items as the most representative of their respective constructs. In contrast, even the lowest loadings (e.g., SE1 at 0.751 and TQ3 at 0.766) remain robust and meaningful. The two items (TQ4 and TQ5) from Perceived Teaching Quality, one item (M1) from Motivation, three items (P3, P5, and P6) in Persistence, and one item (IT1) in Interest were deleted from the scale due to low factor loadings, high cross-loadings as observed in the modification indices, and associated p-values greater than 0.05. Hence, the measurement model improved in terms of psychometric properties and model fit.

Table 1. *Factor Loadings*

Item Code	Factor Loading	p-value
TQ1	0.800	<0.001
TQ2	0.830	<0.001
TQ3	0.766	<0.001
IT2	0.781	<0.001
IT3	0.873	<0.001
IT4	0.776	<0.001
P1	0.843	<0.001
P2	0.913	<0.001
P4	0.806	<0.001
M2	0.843	<0.001
M3	0.837	<0.001
M4	0.810	<0.001
SE1	0.751	<0.001
SE2	0.852	<0.001
SE3	0.876	<0.001
SE4	0.827	<0.001

These results confirm the convergent validity of the constructs, showing that each set of items effectively captures its intended dimension of student attitudes and teaching quality in mathematics. The high loadings across all items reinforce the reliability of the measurement model, validating its use in explaining factors influencing student engagement and persistence. Future refinement efforts may focus on enhancing lower-loading items for improved clarity while ensuring the overall model achieves strong fit indices and discriminant validity for comprehensive validation.

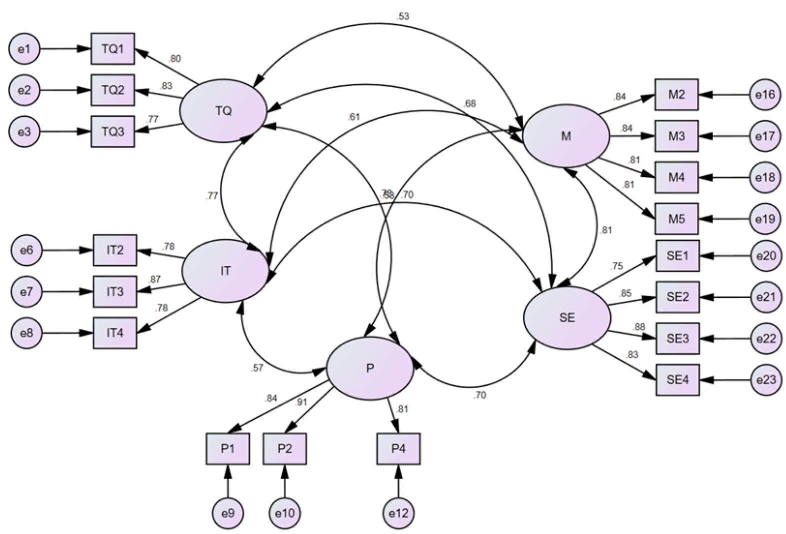

Figure 1. *Measurement Model*

The measurement model shown is a confirmatory factor analysis (CFA) diagram demonstrating the relationships between latent variables and their respective observed indicators. This five-factor model was determined after two modifications. Multiple indicators measure each latent variable, as factor loadings indicate. These loadings represent the strength of the relationship between the latent constructs and their observed variables, with higher values suggesting stronger associations and better construct validity. Moreover, it is observed that the constructs are strongly correlated to each other, with correlation coefficients ranging from 0.751 to 0.913, indicating a high degree of interrelatedness among the constructs. Oamen (2024) mentioned that correlated latent variables typically yield better model fit, enhancing the reliability of the measured constructs. This suggests that latent variables such as Perceived Teaching Quality, Interest, Persistence, Motivation, and Self-Efficacy are both individually significant and collectively contribute to shaping students' attitudes and engagement in mathematics.

The interconnections among the latent variables signify their correlations, which are key in assessing discriminant validity. The adequacy of the model is further supported by factor loadings above the threshold (commonly 0.50

or 0.60), indicating good convergent validity. These aspects of psychometric properties were computed, assessed, and presented in the succeeding tables.

Table 2. *Model Fit Statistics*

Model Fit Indices	Good Fit	Acceptable Fit	Source	Resulting Value Before Modification	Resulting Value after Modification	Verbal Interpretation
CMIN	$0 < \chi^2 < 2df$	$2df < \chi^2 < 3df$	Engel et al. (2003)	567.441, df = 109	196.436, df = 109	Good
p-value	$0.05 < p \leq 1.00$	$0.01 \leq p \leq 0.05$	Engel et al. (2003)	<0.001	<0.001	Acceptable
CMIN/df	$0 \leq \chi^2/df \leq 2$	$2 < \chi^2/df \leq 3$	Engel et al. (2003), Hair et al. (2009)	5.206	1.802	Good
NFI	$0.95 \leq NFI \leq 1.00$	$0.90 \leq NFI \leq 0.95$	Engel et al. (2003),	0.898	0.951	Good
RFI	$RFI \geq 0.95$	$RFI \geq 0.90$	Kline (2016)	0.890	0.939	Acceptable
IFI	$IFI \geq 0.95$	$IFI \geq 0.90$	Mattan et al., (n.d.)	0.873	0.977	Good
CFI	$0.97 \leq CFI \leq 1.00$	$0.95 \leq CFI \leq 0.97$	Hair Jr et al. (2017)	0.902	0.977	Good
GFI	$0.95 \leq GFI \leq 1.00$	$0.90 \leq GFI \leq 0.95$	Engel et al. (2003)	0.868	0.933	Acceptable
TLI	$0.90 \leq AGFI \leq 1.00$	$0.85 \leq AGFI \leq 0.90$	Magno (2021)	0.905	0.972	Good
SRMR	$0 \leq SRMR \leq 0.05$	$0.05 < SRMR \leq 0.10$	Hu & Betler (1999)	0.084	0.013	Good
RMSEA	$0 \leq RMSEA \leq 0.05$	$0.05 < RMSEA \leq 0.08$	Kenny et al. (2014), Engel et al., (2003)	0.078	0.050	Good

The model fit statistics in Table 2 provide a comprehensive evaluation of the structural equation model's alignment with the data, both before and after modifications. Before modification, several indices fell into the acceptable range, indicating a reasonably well-fitting model, but adjustments were necessary to achieve optimal fit. For instance, the CMIN/df ratio improved from 5.206 (not a good fit) to 1.802 (good), signifying a better balance between model complexity and data representation. The CMIN (Chi-Square) value of 567.441 was enhanced to 196.436, which falls in the range of $0 < \chi^2 < 2df$. The p-value associated with CMIN is also below 0.05. These results still indicate substantial model improvement and a strong alignment with the observed data after modification. Similarly, the Root Mean Squared Error of Approximation (RMSEA) decreased from 0.078 to 0.05, moving from acceptable to good, indicating reduced residual error in the modified model. This suggests that the modifications successfully enhanced the model's precision and reliability.

Post-modification results reveal that most indices reached the "good fit" category, demonstrating the model's robustness. Notably, the Comparative Fit Index (CFI) improved from 0.902 to 0.977, exceeding the threshold for a good fit, and the Standardized Root Mean Square Residual (SRMR) dropped to 0.013, reflecting a nearly perfect match between the observed and predicted data. Normed Fit Index (NFI) improved from 0.898 to 0.951, which is the same case as the Relative Fit Index (RFI), which has an initial value of 0.890 being increased to 0.939. Additionally, indices such as the Tucker-Lewis Index (TLI) and Incremental Fit Index (IFI) showed significant enhancements, confirming the model's validity. While the Goodness of Fit Index (GFI) remained slightly below the threshold for a good fit, its movement from 0.868 to 0.933 indicates substantial improvement. These results collectively affirm that the model is well-calibrated to the data and suitable for explaining the relationships among the constructs.

Composite Reliability (CR) is a critical psychometric property that assesses the internal consistency and reliability of latent constructs in a model. Table 3 demonstrates that all latent variables—Perceived Teaching Quality, Interest, Persistence, Motivation, and Self-Efficacy—exhibit CR values well above the commonly accepted threshold of 0.70, indicating strong internal consistency across the constructs. The computed values reveal that each construct in the scale exhibits strong internal consistency, with coefficients surpassing the threshold of 0.70. This aligns with the conservative standard proposed by Shamim (2021) and the guidelines outlined by Nunnally and Bernstein (1994), as referenced by PARSSU (2022). This suggests that the items within each latent variable reliably measure the same underlying construct, confirming their robustness as indicators.

Table 3. *Composite Reliability*

Latent Variable	Number of Items	Composite Reliability
Perceived Teaching Quality	3	0.841
Interest	3	0.852
Persistence	3	0.891
Motivation	4	0.896
Self-Efficacy	4	0.897

Among the constructs, Self-Efficacy (CR = 0.897) and Motivation (CR = 0.896) exhibit the highest composite reliability, underscoring their strong measurement precision and suggesting minimal measurement error. Persistence (CR = 0.891) also displays excellent reliability, reflecting consistent item responses. While Perceived Teaching Quality (CR = 0.841) and Interest (CR = 0.852) have slightly lower CR values than others, they still surpass the standard benchmark, confirming their adequacy. These results collectively affirm the reliability of the measurement model and its suitability for structural equation modeling, enabling confidence in the latent variables' contributions to understanding the study's constructs.

Table 4 provides insights into the convergent and discriminant validity of the constructs in the model, which is essential for evaluating the measurement model's psychometric soundness. Convergent validity is supported by the Average Variance Extracted (AVE) values for all constructs, which exceed the recommended threshold of 0.50, indicating that their respective latent constructs explain more than half of the variance in the observed variables. According to Kock (2020), a research instrument exhibits good convergent validity when respondents interpret the item statements associated with each latent construct in the same way as created by the designers. The Average Variance Extracted (AVE) of each constructed was calculated to determine the variance proportion in the items the latent variable explained (PARSSU, 2022). As observed from the matrix, each average variance extracted exceeds the required value of greater than 0.50, as indicated by Shamim (2021) and Fornell and Larker (1981). The high AVE values, ranging from 0.639 (Perceived Teaching Quality) to 0.731 (Persistence), confirm that the constructs are well-measured by their items.

Table 4. *Convergent and Discriminant Validity*

	Perceived Teaching Quality	Interest	Persistence	Motivation	Self-Efficacy
Perceived Teaching Quality	1	-	-	-	-
Interest	0.770	1	-	-	-
Persistence	0.531	0.570	1	-	
Motivation	0.530	0.606	0.777	1	-
Self-Efficacy	0.681	0.701	0.703	0.812	1
AVE	0.639	0.658	0.731	0.683	0.685
$\sqrt{\text{AVE}}$	0.799	0.811	0.855	0.826	0.828

Discriminant validity is assessed by comparing each construct's square root of the AVE (√AVE) with the correlation coefficients between constructs. To attain discriminant validity, the square root of the average variance extracted should be higher than the correlations with the constructs (Fornell & Larker, 1981). This table compares the correlation values between constructs to the √AVE values to check for discriminant validity. The √AVE values (e.g., 0.799 for Perceived Teaching Quality and 0.855 for Persistence) are higher than the corresponding inter-construct correlations (e.g., 0.770 between Perceived Teaching Quality and Interest and 0.777 between Persistence and Motivation). This indicates that each construct is more strongly related to its items than to items of other constructs, confirming adequate discriminant validity. Notably, the highest correlation (0.812) between Motivation and Self-Efficacy reflects a strong but distinct relationship between these constructs. Overall, the results validate the constructs' ability to independently and accurately measure their respective domains within the model.

3.2 Structural Equation Modeling

The assessment of model fit indices in this CB-SEM analysis provides comprehensive insights into the model's adequacy in explaining the observed data. The CMIN value of 246.783 with 128 degrees of freedom (df) falls within the threshold for a good fit ($0 < \chi^2 < 2\text{df}$). The CMIN/df ratio of 1.928 also falls within the threshold for a good fit ($0 \leq \chi^2/\text{df} \leq 2$). These results indicate that the model closely approximates the observed covariance matrix, validating its structural accuracy. Although the p-value is below 0.001, indicating statistical significance, this is acceptable in large sample sizes where the chi-square test is sensitive.

Table 5. *Model Fit Statistics*

Model Fit Indices	Good Fit	Acceptable Fit	Source	Resulting Value	Interpretation
CMIN	$0 < \chi^2 < 2df$	$2df < \chi^2 < 3df$	Engel et al. (2003)	193.03, df = 112	Good
p-value	$0.05 < p \leq 1.00$	$0.01 \leq p \leq 0.05$	Engel et al. (2003)	<0.001	Acceptable
CMIN/ df	$0 \leq \chi^2/df \leq 2$	$2 < \chi^2/df \leq 3$	Engel et al. (2003), Hair et al. (2009)	1.723	Good
GFI	$0.95 \leq GFI \leq 1.00$	$0.90 \leq GFI \leq 0.95$	Engel et al. (2003)	0.933	Acceptable
CFI	$0.97 \leq CFI \leq 1.00$	$0.95 \leq CFI \leq 0.97$	Hair et al. (2017)	0.979	Good
TLI	$0.90 \leq AGFI \leq 1.00$	$0.85 \leq AGFI \leq 0.90$	Magno (2021)	0.974	Good
NFI	$0.95 \leq NFI \leq 1.00$	$0.90 \leq NFI \leq 0.95$	Engel et al. (2003)	0.952	Good
SRMR	$0 \leq SRMR \leq 0.05$	$0.05 < SRMR \leq 0.10$	Hu & Betler (1999)	0.013	Good
RMSEA	$0 \leq RMSEA \leq 0.05$	$0.05 < RMSEA \leq 0.08$	Kenny et al. (2014), Engel et al., (2003)	0.047	Good

Other fit indices reinforce the model's robustness. The Comparative Fit Index (CFI = 0.979) and Tucker-Lewis Index (TLI = 0.974) exceed the good-fit thresholds (0.95 ≤ CFI ≤1.00, 0.90 ≤ TLI ≤1.00), reflecting excellent model performance in capturing the data's structure. The Standardized Root Mean Square Residual (SRMR = 0.013) further indicates a good fit, as it falls below the stringent 0.05 cutoff. While the Goodness of Fit Index (GFI = 0.933) and Root Mean Square Error of Approximation (RMSEA = 0.047) are in the acceptable ranges (0.90 ≤ GFI < 0.95 and 0 < RMSEA ≤ 0.05), they still suggest a reasonably close model-to-data fit. Lastly, the Normed Fit Index (NFI = 0.952) exhibited a good-fit threshold and remains within acceptable limits, providing further evidence of the model's reliability. These indices collectively confirm the model's adequacy and potential for meaningful interpretation of latent construct relationships.

The structural model diagram (Figure 2) produced by AMOS visualizes the relationships among the latent constructs and their observed indicators in the study. Each oval represents a latent variable, while rectangles denote observed variables. Factor loadings, depicted as values on the arrows connecting latent variables to their indicators, are all above the commonly accepted threshold of 0.50, indicating substantial item contributions to their respective latent constructs. For instance, indicators for Perceived Teaching Quality (TQ1, TQ2, TQ3) exhibit high loadings (e.g., 0.80, 0.76), signifying the construct's strong measurement reliability.

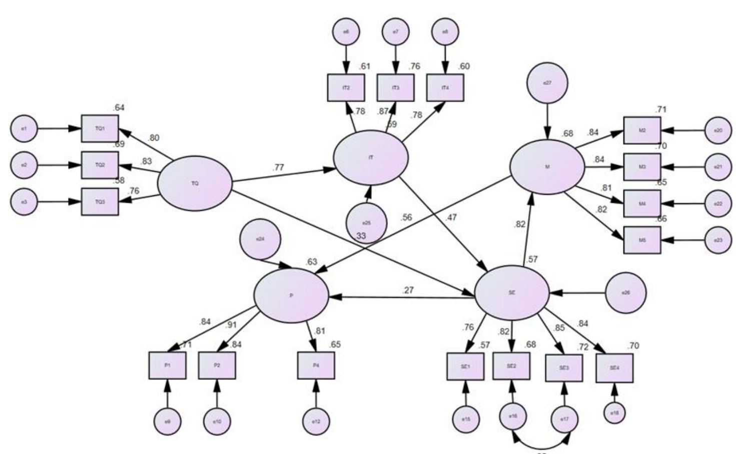

Figure 2. *Structural Model*

The model also displays standardized regression weights for the relationships between latent constructs. For instance, the path from Self-Efficacy (SE) to Motivation (M) shows a strong relationship with a standardized weight of 0.82, indicating that motivation significantly predicts self-efficacy. Similarly, Perceived Teaching Quality (TQ) shows a positive direct influence on Interest (I) with a standardized weight of 0.77, and Interest (I) has a positive direct influence on Self-Efficacy based on the standardized weight of 0.47. Teaching Quality (TQ) positively influences Self-Efficacy (SE), as evidenced by the standardized coefficient 0.33. Motivation (M) and Persistence (P) exhibited a strong relationship based on the standardized coefficient 0.56. Self-efficacy (SE) positively influences Persistence (P) to a weak extent based on the standardized weight of 0.27. The model's inclusion of error terms (e.g., e16, e17) ensures the accounting of measurement error. The structural model illustrates a robust and coherent framework for understanding the relationships among constructs central to student engagement and learning outcomes in mathematics.

The SEM analysis provided a framework having a sound model fit with good measurement or psychometric properties (AVE > 0.50, Composite Reliability coefficients > 0.80, $\sqrt{\text{AVE}}$ > Inter-construct correlations). The structural model estimates in Table 6 provide a detailed evaluation of the hypothesized relationships between variables, with significant paths being supported by robust statistical evidence.

Table 6. *Structural Model Estimates*

	Hypothesized Path	Standardized Coefficient	Unstandardized Coefficient	p-value	Decision
H1	The self-efficacy of the respondents significantly affects their motivation to learn mathematics.	0.823	0.784	<0.001	Supported
H2	Teaching quality significantly affects the respondent's interest in learning mathematics.	0.769	0.773	<0.001	Supported
H3	The motivation of the respondents to learn mathematics significantly affects their persistence.	0.557	0.523	<0.001	Supported
H4	Teaching quality significantly influences the self-efficacy of the respondents.	0.328	0.328	<0.001	Supported
H5	Interest in learning mathematics significantly influences the self-efficacy of the respondents.	0.471	0.469	<0.001	Supported
H6	The self-efficacy of the respondents significantly affects their persistence	0.267	0.239	0.003	Supported

H1: The self-efficacy of the respondents significantly affects their motivation to learn mathematics.

The standardized coefficient of 0.823 indicates a strong positive relationship between self-efficacy and motivation to learn mathematics. The unstandardized coefficient of 0.784, with a p-value of <0.001, confirms the statistical significance of this effect. This result highlights that students with higher levels of self-efficacy are more likely to exhibit greater motivation in learning mathematics, underscoring self-efficacy as a critical determinant of their drive to engage with mathematical tasks. In a broad sense, Ariff et al. (2022) showed in their study that academic motivation and self-efficacy are statistically correlated. Similarly, Detrina (2016) supported the current result based on her study's empirical findings that motivation to learn mathematics is strongly correlated to student's self-efficacy. In the context of distance learning, these results were aligned with the study of Tanaid and Osic (2023), which concluded that academic and emotional self-efficacy were positively correlated to mathematics motivation. In the context of Self-Determination Theory, the students are motivated to learn mathematics when they feel that their actions are self-determined rather than being influenced or controlled by external factors.

H2: Teaching quality significantly affects the respondent's interest in learning mathematics.

With a standardized coefficient of 0.769, the relationship between teaching quality and interest in learning mathematics is also strong and positive. The unstandardized coefficient of 0.773 and a p-value of <0.001 demonstrate that adequate teaching quality significantly enhances students' interest in mathematics. This finding emphasizes the pivotal role of teaching practices in fostering an engaging learning environment for mathematics education. This finding aligns with the one assumption of Social Cognitive Theory, which posits that learning occurs within a social context. Students' interest in learning mathematics is promoted when teachers deliver mathematics instruction effectively. Tambunan et al. (2021) proved that teacher performance significantly influences students' interest in learning mathematics, which, in turn, affects motivation significantly. Furthermore, Zhu and Kaiser (2022) had supporting findings as they revealed that instructional quality significantly influences student's mathematics interest.

H3: The motivation of the respondents to learn mathematics significantly affects their persistence.

The standardized coefficient of 0.557 reflects a moderate positive influence of motivation on persistence in learning mathematics. The unstandardized coefficient of 0.523, with a p-value of <0.001, confirms that motivated students are more likely to persevere in mastering mathematical concepts and skills. This underscores the importance of nurturing student motivation to sustain their long-term commitment to learning. Self-determination theory supports this claim as it posits that when students feel motivated, they are more likely to persist in doing mathematics learning tasks because they find the activity itself as important and rewarding to themselves. Vollmeyer and Rheinberg (2000) concluded that motivation is essential for boosting persistence. Meti et al. (2024) implied that motivation enhances student engagement and effort, reflecting persistence, thereby improving mathematics literacy and problem-solving skills.

H4: Teaching quality significantly influences the self-efficacy of the respondents.
The standardized coefficient 0.328 indicates a moderate positive relationship between teaching quality and self-efficacy. The unstandardized coefficient of 0.328 and a p-value of <0.001 confirm that higher teaching quality can significantly enhance students' confidence in their mathematical abilities. This suggests that effective teaching affects academic performance and fosters self-belief in students. As reflected in the assumption of Social Cognitive Theory, self-efficacy is the positive behavioral transformation in students as they gain confidence and improve their learning within the social context fostered by their mathematics teachers. Sudiyatno et al. (2019) concluded that perceptions of teacher quality are significantly related to the student's self-efficacy. Moreover, Zhu and Kaiser (2022) proved that instructional quality has a moderately significant relationship with mathematics students' self-efficacy.

H5: Interest in learning mathematics significantly influences the self-efficacy of the respondents.
The standardized coefficient of 0.471 indicates a moderate positive influence of interest in learning mathematics on self-efficacy. The unstandardized coefficient of 0.469, with a p-value of <0.001, highlights that students more interested in mathematics are more likely to feel capable of succeeding in the subject. This demonstrates that cultivating interest can directly contribute to building students' confidence. This result aligns with Social Cognitive Theory, highlighting how students' interest in mathematics, shaped by their social interactions and environment, significantly impacts their self-efficacy. Schweder and Raufelder (2022) proved quantitatively that student interest and self-efficacy are significantly correlated in two learning environments. Moreover, the results in this section were also aligned with the findings of Nuutila et al. (2020), which revealed that students' situational interest had a stronger effect on self-efficacy than vice-versa, and both variables also contributed positively to student task performance.

H6: The self-efficacy of the respondents significantly affects their persistence.
The standardized coefficient of 0.267 indicates a weak-to-moderate positive effect of self-efficacy on persistence in learning mathematics. The unstandardized coefficient of 0.239, supported by a p-value of 0.003, confirms the significance of this relationship. This result suggests that students who believe in their mathematical capabilities are more likely to persevere in overcoming challenges and achieving learning goals. This result aligns with Self-Determination Theory, as it underscores how self-efficacy, reflecting a sense of competence, fosters intrinsic motivation that enhances students' persistence in pursuing their goals. In the context of mathematics subject, Selden and Selden (2013) mentioned in their abstract that persistence can be supported by the student's level of self-efficacy, a belief in themselves to succeed in a particular situation. The study concluded that students are more likely to approach tasks with persistence and a willingness to explore when they believe their efforts will lead to personal benefits, emphasizing the critical role of self-efficacy. Halper and Vancouver (2016) inferred that self-efficacy can promote persistence when a person is cognizant of his or her current state of task performance. In a different psychological aspect and direction, Cherewick et al. (2023) produced a structural equation model that proved that persistence and academic self-efficacy are significantly associated with each other both in males and females.

4.0 Conclusion

The results of the SEM analysis emphasize the significant complex relationships between self-efficacy, motivation, teaching quality, and persistence in learning mathematics among public high school students. Self-efficacy emerges as a powerful driver of motivation and persistence, suggesting that students who believe in their mathematical abilities are more motivated and persistent in their learning efforts. This makes them more eager to complete learning tasks assigned to them by their teachers. This finding affirms the assumption of the Self-Determination Theory, which emphasizes the role of intrinsic motivation and competence in fostering persistence. Perceived teaching quality also plays a critical role, as it significantly enhances both students' interest in mathematics and their self-efficacy, reinforcing the social learning context suggested by Social Cognitive Theory. Furthermore, the positive influence of interest on self-efficacy underscores the importance of fostering student engagement, active learning, and interest in building confidence in their mathematical abilities. Maximizing these variables will enable learners to reach their full potential in dealing with mathematics learning tasks. These findings suggest that an effective educational environment, which promotes self-efficacy and motivation to learn through quality and innovative teaching and engaging learning experiences, is integral for enhancing students' persistence and overall academic success in mathematics.

For high school students, it is recommended to actively engage in self-reflection to build self-efficacy, setting small, achievable goals in mathematics to foster confidence and motivation. Math teachers should embrace interactive, student-centered teaching strategies that cultivate interest and self-belief, using real-world applications to make mathematics relevant. School heads and the Department of Education should prioritize professional development programs that equip teachers with innovative methods to boost student motivation, capture interest, and promote a growth mindset despite many distractions among students nowadays. Future researchers could explore integrating digital tools and gamification in the classroom to enhance mathematical persistence, investigating how virtual environments can support the development of self-efficacy and long-term engagement in learning. Moreover, future researchers could further enhance the model by conducting mediation analysis, moderation analysis, or another type of statistical modeling involving unexplored non-cognitive determinants of mathematics learning at the high school level.

5.0 Contributions of Authors

The author takes full responsibility for the study's conceptualization and design, data collection, statistical analysis, and manuscript writing.

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7.0 Conflict of Interests

To avoid potential conflicts of interest, the researcher implemented predefined protocols. Data collection and analysis were conducted relatively, maintaining neutrality and ensuring no direct affiliations or relationships with the participating learners or instrument validators.

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